for twenty-four hours at a temperature of 35°–40° C. (=95°–104° F.) in a solution of one half per cent. of phosphate of soda and ammonia. At a lower temperature it takes longer under otherwise similar conditions before this phenomenon is manifested. Thus it requires four days at about 15° C. (=59° F.) and three weeks at 6° C. (=42°·8 F.). At 0°–5° C. (=32°–41° F.) we see the *Vibriones* &c., which then move less briskly and not so generally, grow in from four to six weeks from the albuminous simple germ-cells into the cylindrico-filiform and the various other above-mentioned forms of amyloid hysterophymata.

As has already been stated, the germs diffused and freely floating in the nutritive fluid are always developed earlier than those enclosed in the cells, as also usually are those contained in the intercellular spaces (see 'Chemismus' &c. p. 35), just as in general the development of the germs between the superimposed membranes of a tissue-cell system advances from without inwards, and this not only in vegetable but also in animal cells, *e. g.* in those of cartilage.

During this development of amyloid hysterophymata the nutritive fluid very soon becomes acid by the formation of lactic and butyric acids.

Under these conditions, at the above temperature there commences a retrogression of the amyloid bodies; the younger cell-vegetations originating in their joint-cells absorb the amyloid without forming fresh, and become developed into small *Dicocci* and *Bacteria*, which are rendered yellow by iodine.

The production of the organic acids promotes the development of the *Vibrio* joint-cells into yeast; an addition of sugar to the fluid containing amyloid hysterophymata, even when it is boiled for hours and with the greatest care, hastens this development of yeast; so also an addition of dilute phosphoric acid, in which even fresh vegetable tissue develops yeast instead of *Vibriones*.

Schaffhausen, February 1876.

XXXVII.—*On the Actinozoan Nature of* Millepora alcicornis, *Dana and Linn.* (*pars*). By R. G. Nelson, Major-General R.E., and P. Martin Duncan, F.R.S. &c.

Every one who has examined the hard parts of a Millepore critically is impressed with the existence of calices, limited beneath by tabulæ, and separated by more or less spongy-looking cœnenchyma consisting of reticulate and excessively

irregular-shaped processes of carbonate of lime. The absence of septa and of a columella, and the difference in the size of the calicular openings, caused the mass to be placed with much doubt amongst the Tabulata by those who are familiar with the other genera of that heterogeneous group. And the results of the examination of the soft parts, made under many difficulties by the late Prof. L. Agassiz, removed the Millepores from the Actinozoa altogether. He wrote as follows in the 'American Journal of Science and Arts,' 2nd series, vol. xxvi. p. 140 (1858):—"The animals of *Millepora* are Hydroid acalephs and not polyps." . . . "I have seen in the Tortugas something very unexpected. *Millepora* is not an Actinoid polyp, but a genuine Hydroid, closely allied to *Hydractinia*." Dana added a note to this statement, "The drawings of Prof. Agassiz which have been sent us for examination are so obviously Hydractinian in most of their characters that no one can question the relation." Alexander Agassiz, in his charming 'Sea-side Studies' (2nd edit. 1871) and in correspondence with one of us, is satisfied with his father's correctness, and gives a drawing of the *Hydractinia*-looking polyp on the surface of *Millepora*.

The importance of these statements need not be explained; and they led L. Agassiz to examine the hard parts of the Tabulata; and he decided that much of them was sclerobasic instead of sclerodermic. It resulted from the general bearing of his researches that the Tabulata and Rugosa were shifted about by succeeding authors according to their belief in them and in the value of the Tabulata as a natural group. The Hydroid nature of *Millepora* was asserted by the majority of naturalists.

There was some dissent, however, from this generalization. Milne-Edwards, in his 'Hist. Nat. des Corall.' vol. iii. p. 224, did not consider the facts elucidated by L. Agassiz to be "assez bien connus," and he did not remove the Millepores from his Tabulata. In the third Report on the British Fossil Corals (Brit. Assoc. for Adv. of Science, 1871), one of us wrote as follows in allusion to L. Agassiz's opinions:—"Now the distinction between the Actinozoa and the Hydrozoa is well marked: in the first the generative apparatus is included in the gastric and perigastric cavities, and in the last the generative and digestive organs are perfectly apart. Every variety of tentacular and disk apparatus may exist in either; but the external development of the gemmules, ova, and embryonic forms must be recognized before any Cœlenterate animal can be associated with the Hydrozoa. Here is the point where Agassiz fails. His researches are only suggestive until the

generative organs are recognized on the protruded polyps of *Millepora*, and until the mesenterico-ovarian layers are proved not to exist within the calices. The external resemblance of the Millepore-polyps to the sterile *Hydractiniæ* is evident." In the same report it is noticed that "*Millepora* is a most aberrant genus if it be one of the Madreporarian Tabulata. I have not yet satisfied myself about the Hydroidean characteristics of its soft parts; but an examination of the cœnenchyma of a series of species throws great doubt upon the Madreporarian affinities." The intimate nature of the hard parts was thus noticed in the same Report, p. 126:—"A careful examination of the calices of good specimens determines that the trabeculæ of which the cœnenchyma is composed often projects into them in the position of septa; but there is nothing like the regular arrangement as seen in *Heliopora* or in the Poritidæ of the Perforata. The cells of the cœnenchyma may occasionally be seen to open into the space above the last tabula. The absence of septa and this relation of the cœnenchyma to the gastric spaces are most important. The tubular nature of much of the cœnenchyma is evident; and longitudinal sections prove that the spongy nature is by no means constant or uniform." In the 'Trans. Connecticut Acad. of Arts and Sciences,' vol. i. 1868–1870, Prof. E. A. Verrill demolished the theory that because *Millepora* is a Hydroid all the other Tabulata belong to the same order. He admits the Hydroid nature of the polyp of *Millepora*, and shows that Bradley has proved that *Pocillopora* has animals identical in structure with most typical genera of true polyps. He notices the twelve septa of the species of this last genus, and that the genus is a true Madreporarian allied to *Oculina* and *Stylophora*. (See also the same author, "On the Affinities of the Tabulate Corals," Proc. Essex Instit. iv. p. 90, 1869.) Bradley described the polyps of *Pocillopora lacera*, Verrill, as having twelve equal cylindrical tentacles, which are swollen at the tips (six are horizontal, and six upright: Verrill, Notes &c. p. 523).

A paper was read at the Royal Society (received Sept. 28, 1875) by H. N. Moseley, M.A., Naturalist to the 'Challenger' Expedition, "On the Structure and Relations of the Alcyonarian *Heliopora cærulea*, with some Account of the Anatomy of a Species of *Sarcophyton*; Notes on the Structure of Species of the Genera *Millepora*, *Pocillopora*, and *Stylaster*; and Remarks on the Affinities of certain Palæozoic Corals." The author examined *Millepora alcicornis* at Bermuda and other species elsewhere, and remarks that "the examination of these Millepores was found to be beset *with great difficulties*," but

trusts to obtain results at the Sandwich Islands*. This difficulty is again referred to (p. 63); but some information is given regarding the question:—"The calcareous cœnenchymal tissue of *Millepora* differs extremely from that of *Heliopora* in being reticulate, not tubular: in histological structure it is similar to *Heliopora*. The coral has only a thin superficial layer of soft living tissue, composed of a network of canals filled with cells resembling those of the canals of Alcyonarians, and covered externally with nematocysts." . . . "Two kinds of polyps are present, large and small. Tentacles are present in both kinds; they appear to be four in number and compound. They are simply retracted by means of muscular fibres, which are arranged round the base of the cylindrical stomach radially, but, as far as has yet been seen, without any disposition in definite groups. No mesenteries have been seen."

Further on the author notices that "*Heliopora* is most *undoubtedly* an Alcyonarian. The number of its mesenteries, the distribution with regard to them of the retractor muscles, and the form and number of its tentacles are decisive evidence in the matter." Yet in a few lines, in spite of what the author had written regarding the similarity of their histological characters, we are told that with the Milleporidæ and with the Pocilloporidæ and Seriatoporidæ, *Heliopora* is allied solely on account of its possession of tabulæ. Mr. Moseley had Prof. Verrill's book to refer to, and yet appears to have forgotten Mr. Bradley's work, which his own researches prove to be correct.

Evidently in extreme perplexity, like most of us who have ventured to touch the subject of the Millepores, Mr. Moseley determines that "no certain conclusion can be arrived at from the few facts yet ascertained." In other words, the question of the structure and affinities is perfectly open.

Many years ago one of us, then Lieut. Nelson, R.E., was quartered at Bermuda; and the geological description of the Islands in the 'Transactions of the Geological Society' † was one of the results of some study there. The structure of *Millepora alcicornis* was also made a study, and drawings were

* Proc. Royal Soc. vol. xxiv. no. 164, p. 60. The author remarks:—"Few original works relating to the subjects treated of in this paper were available for reference on board the 'Challenger.'" We suppose that the whole of the writings of one of us regarding the Rugosa, in the 'Phil. Trans.,' the Palæontographical Society's publications (Secondary Corals), the papers on Australian corals, and the reports on the Tabulata and Rugosa were not there. In explaining his views regarding the Rugosa the author simply mistakes our meaning in relation to the origin of that group.

† "On the Geology of the Bermudas," Trans. Geol. Soc. 1834, 2nd ser. vol. v. p. 103.

taken of it under advantageous circumstances. For many years these drawings have been on the point of being published, and now, owing to their manifest importance, they are brought forward. In the mean time, and especially of late years, since the Tabulata were considered in the Report to the British Association already noticed, the other contributor to this paper has microscopically examined many specimens, and has worked up to the point where Lieut. (now Major-General) Nelson's long-completed work began.

There is little to add to the description of the hard parts, except to notice that all are agreed in their construction, and that the tubular nature of the cœnenchyma relates to old polyp-calices in long series, the tabulæ having been absorbed or broken down. The reticulate appearance on the surface is produced by well-marked ridges and depressions; and cavities exist below the surface in this reticulate mass, which are connected with the calicular spaces. The tissue soon becomes hard and more solid with depth; and infiltration of carbonate of lime appears to have united the reticulate sclerenchymatous processes. But in the midst of branches the reticulate and apparently cellular arrangement persists. The sclerenchyma consists of fibrous-looking plain spicula, arranged side by side and above each other; there are also homogeneous carbonate of lime and granules. The soft tissues (or rather the organic basis which permeates the coral, and in and about which the calcareous element is deposited) are much more plentiful than might be expected; they can be got out by weak hydrochloric acid (dilute), and evidently line the calicular fossæ, the top of the tabulæ, and enter into the cavities in the reticulate superficial structure. The shape of the solid parts of the reticulation is retained by this means, sometimes very perfectly. Once only was a glimpse obtained of any thing like a polyp; and it foreshadowed the truth long before obtained at the Bermudas.

The polyp of *Millepora alcicornis*, as seen by one of us at Bermuda in full expansion, is a very remarkable one; and it is a great satisfaction to be able to state that L. Agassiz saw only a part of the whole, and came to his conclusions too rapidly. The polyps are of different lengths according to their growth, are slender, and stand erect in crowds around the branches (fig. 2). Each arises from a cylindrical stem, which is rendered slightly square close to four tentacles which project upwards and outwards. Their tips are swollen and rounded; and their bases are continuous by means of straight disk tissue which overlaps slightly the analogue of the oral opening. Out of this opening comes a second cylinder, to terminate in four other tentacles in the same way; and in some polyps there is a further growth; so that there are two or more rows of tentacles separated

by the tubular cylindrical tissue (fig. 1). It is evident that Agassiz saw young, ill-developed, and probably injured polyps which had not attained their second row of tentacles.

The number of tentacles may be therefore 4, 8, 12, &c. The tentacles were not noticed to be pinnate *.

In looking at this description there is a probability that *Millepora* is an Alcyonarian; and there is no proof that it is a Hydroid. The arrangement of the sclerenchyma will prevent the species being classified as Madreporarian.

Fig. 1.

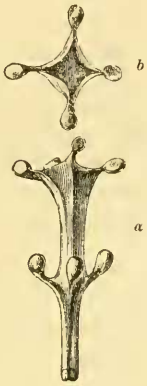

Fig. 2.

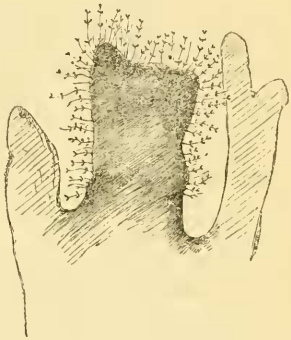

Fig. 3.

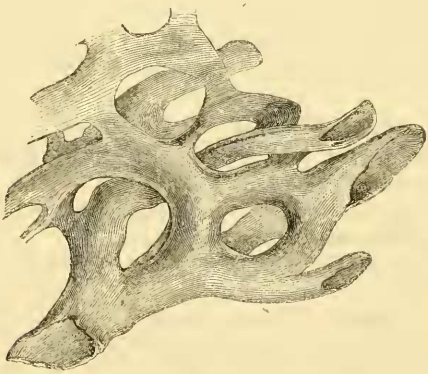

Fig. 1. Expanded polyp of *Millepora alcicornis*: *a*, side view (in some instances there are five or six whorls of tentacles); *b*, view of top.
Fig. 2. Corallum with expanded polyps.
Fig. 3. The tubular cavities of the corallum.
From drawings by Lieut. (now Major-General) Nelson, R.E.

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* Pinnate tentacles are not peculiar to Alcyonarians. *Oculina diffusa* of Bermuda has them.